

cable aloft, landing more than 1,000 feet away. It was fired at night, but a burning saltpeter fuse, attached to the arrow-head, traced its path in the darkness.

My first use of kites of specific size with which to measure the wind velocity by means of a pull on a spring balance, as compared with the record of the anemometer at a similar height at the New York Weather Bureau station was made early in 1894, but was elaborated with many classified observations on December 18, 1897.

My first self-illuminated, single plane kite ascended March 26, 1898, with the lighted lantern within six inches of the surface of the kite. My first simultaneous kite temperatures were taken at New York and Bayonne, N. J., April 9, 1898. Mr. Henry L. Allen operated the kites at Bayonne and I operated those in New York. (See MONTHLY WEATHER REVIEW, April 1898, p. 161.) The United States flag was first brilliantly illuminated by colored fire, also suspended in mid-air near the flag on April 30, 1898. My first dynamite messenger war kite ascended under wind pressure on April 2, 1898, and the first shooting-star war signal lantern was released at a height of about 900 feet, and descended by gravity down the kite cable at 8 p. m., June 17, 1898.

Prof. S. P. Langley, in March or April, 1894, sent me a grant from the Hodgkins fund for the purpose of experiment with silk cord in reaching a great altitude with kites. My experiments with silk cord, which extended over more than a year, demonstrated that while silk was very strong for its weight, about twice as strong for its weight as compared with steel, as demonstrated by Professor Thurston, of Cornell University, yet its tensile strength was too unequal owing to fraying or attrition of its surface, and in my report to the Smithsonian Institution I recommended the use of flax with a steam engine for winding in the kite cable. The steam engine at Blue Hill Observatory was established by cooperation with the Hodgkins fund, steel wire being used, that standing next to silk in tensile strength, as related to its weight. Steel wire was used as kite cable by Archibald in 1884, as described in *Nature*, in 1886.

Since about five miles of wire were run out at Blue Hill Observatory to reach 11,494 feet above the summit of the hill on August 26, 1898, with 149 square feet of kite surface, it seems to me that at great heights the increasing wind velocity with height may not quite compensate for loss of pressure due to rarefaction of the air. Important estimates remain to be made in this direction.

On July 28, 1898, by telegraphic orders from Gen. A. W. Greeley, I sent 26 of my kites and other apparatus to Newport News, Va., to demonstrate in Puerto Rico, experimentally, the value of kites for photographing the enemy's fortifications. The report of Col. W. A. Glassford, who has charge of the apparatus, has not yet reached me. I have, however, heard indirectly that my kites have been successfully used for military flag signaling in Puerto Rico.

THE EFFECT OF PROXIMITY TO THE SEA ON THUNDERSTORM PERIODS.

By HERMAN D. STEARNS, Associate Professor of Physics, Leland Stanford, Jr., University, Palo Alto, Cal.

In a paper on "Thunderstorms and unstable equilibrium in the atmosphere" (*Meteorologische Zeitschrift*, April, 1895), Prof. Wilhelm von Bezold has given a number of reasons for expecting a difference in the daily and yearly thunderstorm periods when inland observations are compared with those made on or near the sea.

Von Bezold accepts Mohn's division of thunderstorms into the two classes: Heat and cyclonic thunderstorms. The heat thunderstorms are regarded as due to the breaking up of a condition of unstable equilibrium in the atmosphere; the

resulting rapidly ascending current forms the necessary thunderstorm condition. The cyclonic thunderstorms accompany the general cyclonic storms and find their condition in the ascending current at the center of the cyclone.

Three causes for unstable equilibrium in the atmosphere are cited: (a) overheating of the lower layers of the atmosphere, first mentioned by Reye; (b) overcooling of the higher atmospheric layers, first pointed out by Prof. W. M. Davis; (c) a sudden change of state in the atmosphere, such as a sudden condensation of water vapor or a sudden freezing of suspended water.

The overheating of the earth's surface on hot, still summer afternoons accounts for the well-marked summer afternoon maximum shown by inland observations. The wind and the cooling influence of the water prevent so marked a summer afternoon maximum on the sea.

Unstable equilibrium due to overcooling of upper atmospheric layers is not so easily accounted for, because the necessary condition for rapid cooling would seem to be either wind or cloud, the wind to introduce cold air from other regions, the cloud to produce cooling by rapid radiation from its upper surface. But the wind itself would prevent a condition of unstable equilibrium, and a cloud is usually caused by the ascending current of a cyclone, which would likewise prevent an unstable condition. The cooling due to the cloud would, however, cause an increased velocity in the ascending cyclonic current, and hence would increase the probability of a cyclonic thunderstorm. This phenomenon would be most frequent in the case of the low-hanging clouds over the moist air above the sea and the coast on winter nights. The result would be an increase in the number of winter-night cyclonic thunderstorms on the sea and the coast.

The so-called supersaturation of the atmosphere with water vapor would (if this phenomenon takes place in the free atmosphere) be more probable on the sea than inland, because of the greater probability of the presence of dustless air, and would be most likely to occur over the tropical sea, with its great evaporation. The sudden condensation of this vapor, accompanied by the resulting ascending current, would make a thunderstorm probable.

Unstable equilibrium due to the overcooling of water suspended in clouds and the thunderstorms likely to occur on the sudden freezing of this water are evidently as probable on the sea as on the land, and would generally be winter-night phenomena.

Hence, Professor von Bezold concludes that winter and night thunderstorms, compared with summer and afternoon thunderstorms, should be much more frequent on the sea and the coast than inland, but that this effect can scarcely be expected in the case of seacoasts where the paths of the cyclones are generally from the land to the sea, as is usually the case on east coasts in our latitude.

The work of Messrs. Mohn and Hildebrandson on Norway and Sweden and of Dr. Meinardus on the open sea show a general agreement with the above theory, as do, also, other more or less complete reports for different places.

At the suggestion of Professor von Bezold, who permitted me to use the excellent library of the Meteorological Institute at Berlin, and who, with his associates, showed me every kindness, I have tried to add something to the work already published. My work has been confined almost entirely to the yearly period of thunderstorms, and the results appear in the tables below. The tables are followed by the curves showing graphically the monthly percentages in such cases as afford a basis for comparison.

ICELAND.—COAST STATIONS.

The material is taken from the yearly Danish reports. The observations for one station in August, 1893, are wanting.

Otherwise the reports are complete for each station for the time periods selected.

Time periods.	No. years.	No. stations.	Thunderstorms reported.											
			Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1876-1880	5	4	6	4	4	0	0	0	0	0	1	0	0	7
1881-1885	5	7	10	19	3	4	0	0	0	1	3	2	11	67
1886-1890	5	8	8	3	3	1	0	0	1	0	1	4	5	31
1891-1893	3	8	2	3	1	0	0	1	1	1	1	2	3	18
Total, 1876-1893	18	6.6*	26	29	11	5	0	1	8	2	9	8	13	138
Average per station per year			0.2	0.2	0.1	0	0	0	0.1	0	0.1	0.1	0.1	0.2
Monthly percentage			18.8	21.0	8.0	3.6	0.0	0.7	5.8	1.5	6.5	5.8	9.4	18.8

*Average.

FAROE ISLANDS.

The material is taken from the yearly Danish reports. The reports are complete except for one station, February, 1886, and one October, 1890.

Time periods.	No. years.	No. stations.	Thunderstorms reported.											
			Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1876-1880	5	1	2	0	1	1	0	0	0	0	0	0	1	0
1881-1885	5	2	1	0	0	1	0	0	0	0	0	1	2	14
1886-1890	5	2	1	0	0	0	0	0	0	0	0	1	1	24
1891-1893	3	2	1	0	0	0	0	0	0	0	0	1	1	10
Total, 1876-1893	18	2	10	0	3	2	3	4	9	2	4	2	5	58
Average per station per year			0.3	0	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.2
Monthly percentage			18.9	0	5.7	3.8	5.7	7.6	17.0	3.8	7.6	3.8	9.0	17.0

Except when otherwise stated, the tables immediately following were compiled on the same plan as those for Iceland and the Faroe Islands. That is, only those stations have been used for each time period whose reports are complete for this period. As far as possible the time periods chosen have been five years. In a very few cases the result for one station for one month has been obtained by interpolation. Only the combined results for the several time periods are here tabulated.

SCOTLAND (INCLUDING THE ORKNEY ISLANDS) 1881-1893.¹

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Thunderstorms reported—													
North and west coast	26	27	5	21	66	45	57	48	27	34	34	38	423
East coast	4	2	1	14	35	35	77	50	26	7	4	2	257
Inland	19	7	10	35	128	107	156	131	49	36	13	17	708
Average per station per year—													
North and west coast	0.5	0.5	0.1	0.4	1.2	0.8	1.0	0.8	0.5	0.6	0.6	0.7	7.7
East coast	0.1	0.0	0.0	0.3	0.8	0.8	1.7	1.1	0.6	0.2	0.1	0.0	5.7
Inland	0.2	0.1	0.1	0.4	1.5	1.2	1.8	1.5	0.6	0.4	0.1	0.2	8.1
Monthly percentage—													
North and west coast	6.1	6.4	1.2	5.0	15.6	10.6	13.5	10.2	6.4	8.0	8.0	9.0	.....
East coast	1.6	0.8	0.4	5.4	13.6	13.6	30.0	19.5	10.1	2.7	1.6	0.8	.....
Inland	2.7	1.0	1.4	4.9	18.1	15.1	22.0	18.5	6.9	5.1	1.8	2.4	.....

IRELAND, 1881-1893.¹

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Thunderstorms reported—													
Center and west	19	10	4	17	32	57	41	41	16	15	16	10	278
East	3	5	5	12	31	63	68	68	20	15	7	2	299
Average per station per year—													
Center and west	0.3	0.2	0.1	0.3	0.5	0.9	0.6	0.6	0.2	0.2	0.2	0.2	4.3
East	0.1	0.1	0.1	0.3	0.7	1.4	1.5	1.5	0.4	0.3	0.2	0.0	6.6
Monthly percentage—													
Center and west	6.8	3.6	1.4	6.1	11.5	20.5	14.8	14.8	5.8	5.4	5.8	3.6	.....
East	1.0	1.7	1.7	4.0	10.3	21.1	22.8	22.8	6.7	5.0	2.3	0.7	.....

ENGLAND AND WALES, 1881-1893.¹

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Thunderstorms reported—													
West coast	6	0	8	15	55	59	46	48	27	37	22	14	346
South coast	21	23	6	38	95	85	135	105	74	58	32	20	692
East coast	3	3	17	48	135	164	244	153	67	31	5	5	865
Inland	12	13	27	141	333	359	485	344	155	94	31	22	2,016
Average per station per year—													
West coast	0.1	0.2	0.2	0.3	1.1	1.2	0.9	1.0	0.5	0.7	0.4	0.3	6.9
South coast	0.3	0.3	0.1	0.6	1.4	1.2	2.0	1.5	1.1	0.9	0.5	0.3	10.2
East coast	0.1	0.1	0.3	0.8	2.2	2.6	4.1	2.5	1.1	0.5	0.1	0.1	14.5
Inland	0.1	0.1	0.2	1.0	2.3	2.5	3.4	2.4	1.1	0.6	0.2	0.2	14.1
Monthly percentage—													
West coast	1.7	2.6	2.3	4.3	15.9	17.1	13.3	13.9	7.8	10.7	6.4	4.0	.....
South coast	3.0	3.3	0.9	5.5	13.7	12.3	19.5	15.2	10.7	8.4	4.6	2.9	.....
East coast	0.3	0.3	2.0	5.6	15.6	17.8	28.2	17.7	7.8	3.6	0.6	0.6	.....
Inland	0.6	0.6	1.3	7.0	16.5	17.8	24.1	17.1	7.7	4.7	1.5	1.1	.....

HOLLAND, 1882-1896.²

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Thunderstorms reported	172	143	501	2,064	7,093	8,057	11,099	7,897	5,401	3,202	632	318	46,579
Monthly percentage	0.4	0.3	1.1	4.4	15.2	17.3	23.8	17.0	11.6	6.9	1.4	0.7	.....
Average number of days of thunderstorms per year in Holland	2.7	1.3	3.6	6.4	13.9	14.9	16.6	15.0	10.3	10.8	4.1	2.5	102.1
Monthly percentage	2.7	1.3	3.5	6.3	13.6	14.6	16.3	14.7	10.1	10.6	4.0	2.5	.....

¹ The material is taken from the reports for "stations of the second order."

² The material is taken from the volumes entitled *Onweders in Nederland*, in which the yearly summaries are complete and the 5-year periods are partly worked out. No marked geographical distribution of the thunderstorms of Holland could be found.

FRANCE, 1891-1895.¹

	January.	February.	March.	April.	May,	June.	July.	August.	September.	October.	November.	December.	Year.
Total days of thunderstorms—													
Departments on northwest coast	31	10	36	116	169	180	260	207	165	120	89	47	1,880
Departments on west coast	61	42	62	183	224	260	275	226	210	168	77	35	1,823
Departments on Mediterranean coast	26	33	69	169	297	336	332	287	231	165	71	17	2,033
Island of Corsica	44	15	31	34	56	48	40	35	43	52	31	29	458
Departments in the interior	143	150	606	1,453	2,574	2,885	3,129	2,321	1,771	1,034	277	157	16,500
Monthly percentage—													
Departments on northwest coast	2.2	0.7	2.6	8.4	12.3	13.1	18.8	15.0	12.0	8.7	2.8	3.4	.....
Departments on west coast	3.4	2.3	3.4	10.0	12.3	14.3	15.1	12.4	11.5	9.2	4.2	1.9	.....
Departments on Mediterranean coast	1.3	1.6	3.4	8.3	14.6	16.5	16.3	14.1	11.4	8.1	3.5	0.8	.....
Island of Corsica	9.6	3.3	6.8	7.4	12.2	10.5	8.7	7.6	9.4	11.4	6.8	6.3	.....
Departments in the interior	0.9	0.9	3.7	8.8	15.6	17.5	19.0	14.1	10.7	6.3	1.7	1.0	.....

THE SPANISH PENINSULA, 1881-1894.²

Thunderstorms reported—													
West and southwest coasts	124	72	117	142	154	124	97	58	109	113	110	69	1,299
North coast	19	33	30	55	89	135	113	92	83	39	36	32	756
Mediterranean coast	8	16	19	73	44	70	70	51	123	59	13	11	537
Interior	22	42	145	344	619	816	676	596	615	184	37	15	4,061
Monthly percentage—													
West and southwest coast	9.5	5.5	9.0	10.9	11.8	10.1	7.5	4.5	8.4	8.7	8.5	5.3	.....
North coast	2.5	4.4	4.0	7.3	11.8	17.8	14.9	12.2	11.0	5.2	4.8	4.2	.....
Mediterranean coast	1.4	2.9	3.4	13.1	7.9	12.6	12.6	9.2	22.1	10.6	2.3	2.0	.....
Interior	0.5	1.0	3.6	8.5	15.2	20.1	16.6	14.7	15.1	3.3	0.9	0.4	.....

ALGIERS, 1881-1895.³

Thunderstorms reported—													
Coast stations	144	98	143	159	146	164	159	95	249	163	93	100	1,713
Stations near the coast	35	39	46	125	150	150	140	136	205	101	34	31	1,192
Interior	2	30	64	104	164	239	265	185	201	95	27	9	1,385
Average per station per year—													
Coast stations	1.5	1.0	1.5	1.7	1.5	1.7	1.7	1.0	2.6	1.7	1.0	1.1	18.0
Stations near the coast	0.6	0.7	0.8	2.3	2.7	2.7	2.6	2.5	3.7	1.8	0.6	0.6	21.6
Interior	0.0	0.4	0.8	1.4	2.2	3.2	3.5	2.5	2.7	1.3	0.4	0.1	18.5
Monthly percentage—													
Coast stations	8.4	5.7	8.3	9.3	8.5	9.7	9.3	5.5	14.5	9.5	5.5	5.8	.....
Stations near the coast	2.9	3.3	3.9	10.5	12.6	12.6	11.7	11.4	17.2	8.5	2.8	2.6	.....
Interior	0.1	2.2	4.6	7.5	11.8	17.3	19.1	13.4	14.5	6.9	2.0	0.6	.....

ITALY, 1881-1887.⁴

Thunderstorms reported—													
West, south, and southeast coasts (Porto Maurizio-Foggia)	588	282	663	1,493	1,441	2,334	1,967	2,526	2,370	1,503	697	745	16,597
Northeast coast (Chieti-Udine)	79	45	254	1,127	1,803	3,137	2,488	2,374	1,495	719	154	89	13,754
Interior (southeast)	187	103	407	1,447	1,623	3,065	2,464	2,849	1,926	1,095	323	289	15,778
Interior (north)	56	11	570	2,919	4,390	9,074	7,624	6,061	3,769	1,124	197	72	35,867
Sicily	285	249	286	415	317	415	312	599	805	582	352	266	4,873
Sardinia	8	12	29	101	69	60	31	36	35	22	10	24	437
Monthly percentage—													
West, south, and southeast coasts	3.6	1.7	4.0	9.0	8.7	14.0	11.8	15.2	14.3	9.1	4.2	4.5	.....
Northeast coast	0.6	0.3	1.8	8.2	13.1	22.8	18.1	17.2	10.9	5.2	1.1	0.6	.....
Interior, southeast	1.2	0.7	2.6	9.2	10.3	19.4	15.6	18.1	12.2	6.9	2.1	1.8	.....
Interior, north	0.2	0.0	1.6	8.1	12.2	25.3	21.3	16.9	10.5	3.1	0.5	0.2	.....
Sicily	5.9	5.1	5.9	8.5	6.5	8.5	6.4	12.1	16.5	12.0	7.2	5.5	.....
Sardinia	1.8	2.7	6.6	23.1	15.8	13.7	7.1	8.2	8.0	5.0	2.3	5.5	.....

MALTA, 1866-1886.⁵

Thunderstorms reported	13	4	12	7	12	8	2	14	33	50	29	22	206
Monthly percentage	6.3	1.9	5.8	3.4	5.8	3.9	1.0	6.8	16.0	24.3	14.1	10.7	.....

PALMA DE MALLORCA, 1866-1894.⁶

Thunderstorms reported	7	11	12	13	11	23	23	19	45	26	10	9	209
Monthly percentage	3.4	5.3	5.7	6.2	5.3	11.0	11.0	9.1	21.5	12.4	4.8	4.3	.....

¹The material is taken from Fron's yearly summaries in Annales de France. For each department Fron gives the number of days in each month on which a thunderstorm was reported at any station in the department. The tables here given are simply the totals obtained by adding the results given by Fron for all the departments in the regions considered.

²The reports for one station (Gibraltar) are taken from the English records. All other material is taken from the Spanish official reports, and no station is considered for which the reports are not definite and complete.

³The material is taken from Annales de France.

⁴The material is taken from Dr. Ferrari's reports where the yearly summaries are given by provinces.

⁵The material is taken from the English reports for one station.

⁶The material is taken from the Spanish reports.

While the international agreement as to thunderstorm reports has removed much of the vagueness of the earlier reports, nevertheless the results just given can not be regarded as having a high degree of accuracy, and the amount of material is in many cases far too small for a proper determination of the yearly period.

However, the general law that in our latitude the percentage of winter thunderstorms falls off in passing from the coast inland in the general direction of the prevailing cyclonic winds seems established. As was to be expected, the opposite coasts do not show a corresponding increase in the percentage of winter thunderstorms, but, on the contrary, frequently show a decrease.